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American Meteorological Journal.

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THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. IV. ANN ARBOR, AUGUST, 1887. NO. 4.

CURRENT NOTES.

TORNADOES.—The number of tornadoes recorded in the United States between January 1st and June 11, 1887, is 125.

FROSTS.—The Chief Signal Officer in his special Bulletin for June, says that no destructive frosts were reported from any Signal Service station for that month. The mean temperature in places liable to frosts, has been higher than usual.

MALTA, July 25.—A violent volcanic eruption has occurred on the island of Galita, off the coast of Tunis. Streams of lava are issuing from the crater of the volcano, and the glare of the flames emitted is visible for fifty miles.—*Chicago Times.*

METEOROLOGICAL SERVICE AT CORDOBA.—A circular letter from Dr. Oscar Doering, announces that the government of the Province of Cordoba, has founded a meteorological service. Its chief object will be the exploration of the climate of this province, which offers a field of unusual variety and interest. This service begins with forty stations, and is under the direction of Dr. Doering.

AN EXTRAORDINARY DEATH-RATE.—For the week ending Saturday, July 23, the number of deaths in Chicago was 720, as against 294, for the corresponding week a year ago. Of this number 344 died Sunday, July 17, (the hottest day of the season).

There were 185 sunstrokes during the week, besides other deaths directly attributable to the torrid weather. This is the greatest number of deaths in one week, which has ever been known in the history of Chicago.

Island Volcano.—San Francisco, July 18.—The schooner Dora, from Ounalaska, arriving here to-day, brings news that the volcano of Akautan, on the island of Akautan, one of the Aleutian group, is in a state of eruption. The natives state that the eruptions have been almost constant since the middle of May. Loud explosions occur every few moments, and large quantities of rock are thrown up hundreds of feet into the air. At night numerous streams of lava can be seen coursing down the mountain sides, illuminating the whole country around. Earthquake shocks are also frequent.—*Chicago Times.*

The Rio Grande.—This remarkable river, 1,500 miles in length, measured in its windings, is unnavigable save in the tide-waters at its very mouth. The only boats ever seen on its surface are encountered at the few rude ferries for transporting men and merchandise across its current at high water. The volume of its waters is great, but they flow mainly below the river bed, percolating the sands of its wide valley. Water may always be found in the Rio Grande valley by digging wells to the depth of the river's surface. Beginning in the Colorado mountains, a clear, sparkling stream, the Rio Grande soon becomes turbid with sand. In Southern New Mexico, below the town of Albuquerque, it flows through a region of soft alkaline earth; here, also, it is joined by the thick current of the Rio Puerco (nasty river) coming in from the west, and thereafter its waters become extremely muddy. Except in times of flood, the amount of water in sight is remarkably small for so long a river. The current is very swift, and the channel abounds in shoals and quicksands. In places the water sucks through the narrow passage between a sand bar and the shore, and again widens into a broad, rippling current but few inches deep. In very dry times the water, in places, disappears, flowing wholly

through the sands beneath the channel, which is left dry and may be used as a roadway. In this connection Alexander von Humboldt records a notable instance of the disappearance of the Rio Grande from its bed. He wrote:

"The inhabitants of the Passo (El Paso) have preserved the recollection of a very extraordinary event which took place in 1752. The whole bed of the river became dry all of a sudden for more than thirty leagues above and twenty leagues below the Paso, and the water of the river precipitated itself into a newly formed chasm and only made its reappearance near the Presidio de San Eleazario. This loss of the Rio del Norte remained for a considerable time; the fine plains which surround the Passo, and which are intersected with small canals of irrigation, remained without water, and the inhabitants dug wells in the sand with which the bed of the river was filled. At length, after the lapse of several weeks, the water resumed its ancient course."

The floods of the Rio Grande are terrific. Whether arising from heavy rains, or the melting of snows in the mountains, they roll down, an avalanche of muddy water, overspreading the valley and sweeping all before them. They frequently force for the river a new channel, and, where the valley is wide and level, the depressions of the old watercourses can easily be traced. A few years ago, the inhabitants of the considerable town of Mesilla, in New Mexico, which stood on the west bank of the Rio Grande, woke one morning to find the river flowing on the west of their town in a new channel, which it has continued to occupy ever since. Other similar freaks of the river are matters of history both remote and recent in New Mexico.

Most of the streams of New Mexico flow into the Rio Grande. A few rising on the west of the continental "divide" empty into the Rio Colorado in Arizona, and one or two having their source on the eastern slope, in the extreme north of the territory, are tributaries of the Arkansas River. They have the common characteristic of beginning in the mountains, cold, clear, trout streams, which become warm and alkaline, and usually diminish in size as they flow out on the plain.—*Bulletin Am. Geogr. Soc.*

Royal Meteorological Society.—The concluding meeting of this Society for the present session was held on Wednesday

evening, the 15th instant, at the Institution of Civil Engineers, 25 Great George Street, Westminster, Mr. W. Ellis, F. R. A. S., President, in the chair.

The following papers were read:

(1) "Amount and Distribution of Monsoon Rainfall in Ceylon generally, with remarks upon the Rainfall in Dimbula." By Mr. F. J. Waring, M. Inst. C. E. The principal feature in Ceylon as determining both the amount and distribution of rainfall is a group of mountains situated in the South central portion of the Island, equidistant from its east, west, and southern shores. The southwest and northeast Monsoons in Ceylon may be said respectively to blow steadily from May to August inclusive, and from November to February inclusive. In March and April, and in September and October, the weather is more or less unsettled, and no regular Monsoon or direction of the air current is usually experienced. After giving details of the rainfall at 25 stations, the author concludes by remarking upon: (1) The effect of the mountain zone in determining the amount and distribution of the rainfall; (2) The apparent gradual veering of the rain-bearing currents of air as each Monsoon progresses; (3) The relative insignificance of the southwest Monsoon as compared with the northeast Monsoon in inducing rainfall; (4) The cause of the large general rainfall of the northeast Monsoon throughout the Island generally as compared with that of the southwest Monsoon; and (5) The influence of the gaps in the external ring of the mountain zone, and of the central as well as the other ridges in it, in determining the amount of rainfall within the zone and in the neighboring districts outside it.

(2) "Note on a display of Globular Lightning at Ringstead Bay, Dorset, on August 17th, 1876." By Mr. H. S. Eaton, M. A., F. R. Met. Soc. Between 4 and 5 P. M., two ladies who were out on the cliff saw, surrounding them on all sides and extending from a few inches above the surface to two or three feet overhead, numerous globes of light, the size of billiard balls, which were moving independently and vertically up and down, sometimes within a few inches of the observers, but always eluding the grasp; now gliding slowly upwards two or three feet, and

as slowly falling again, resembling in their movements soap bubbles floating in the air. The balls were all aglow, but not dazzling, with a soft superb iridescence, rich and warm of hue, and each of variable tints, their charming colors heightening the extreme beauty of the scene. The subdued magnificence of this fascinating spectacle is described as baffling description. Their numbers were continually fluctuating, at one time thousands of them enveloped the observers, and a few minutes afterwards the numbers would dwindle to perhaps as few as twenty, but soon they would be swarming again as numerous as ever. Not the slightest noise accompanied this display.

(3) "Ball Lightning seen during a Thunder-storm on July 11th, 1874." By Dr. J. W. Tripe, F. R. Met. Soc. During this thunderstorm the author saw a ball of fire of a pale yellow color, rise from behind some houses, at first slowly, apparently about as fast as a cricket ball thrown into the air, then rapidly increasing its rate of motion until it reached an elevation of about 30°, when it started off so rapidly as to form a continuous line of light, proceeding first east then west, rising all the time. After describing several zigzags it disappeared in a large black cloud to the west, from which flashes of lightning had come. In about three minutes another ball ascended, and in about five minutes afterwards a third, both behaving as the first and disappearing in the same cloud.

(4) "Appearance of Air Bubbles at Remenham, Berkshire, January, 1871." By Rev. A. Bonney. Between 11 and 12 A. M., a group of air bubbles of the shape and apparent size of the colored india-rubber balls that are carried about the streets were seen to rise from the center of a level space of snow within view of the house. The bubbles rose to a considerable height, and then began to move up and down within a limited area, and at equal distances from each other, some ascending, others descending. These lasted about two minutes, at the end of which they were borne away by a current of air towards the east and disappeared. Another group rose from the same spot, to the same height, with precisely the same movements, and disappeared in the same direction, after the same manner.

Mr. H. C. Russell, F. R. S., of Sydney, described a fall of red rain, which occurred in New South Wales, and exhibited under the microscope specimens of the deposit collected in the rain-gauges.

In Bulletin No. 7 of the California Academy of Science, Dr. C. M. Richter discusses "Ocean Currents Contiguous to the Coast of California." The principal results obtained are graphically represented by means of a series of seven neatly colored plates showing the velocity and direction of the surface and under-surface ocean currents, the temperature of the water at various distances from the main land and at various depths below the surface. The author states that the sea-thermometer is the most delicate instrument known for determining the character of ocean currents; all the other instruments that have been invented for this purpose he considers unreliable. In 1873 Commander Belknap, while searching for a practicable route for a submarine cable between the United States and Japan, made, among other observations, a series of temperature determinations of the ocean water at various depths, and it is from a discussion of these observations that the main results of the present investigation are derived.

To show how, on theoretical grounds, the existence of an eddy current, having a northerly direction, can be explained, the author calls attention to Zoeppritz's theory of ocean currents in which the prevailing wind plays an important part.

We quote the closing lines of the pamphlet: "The isothermal lines of the ocean for different months at different distances from shore, and along the entire west coast of the United States, should be established beyond doubt. They will form the constant factor for the calculations of our meteorologists. They will probably explain the formation of our barometric maxima and minima, and will enable us to make weather predictions with more accuracy than it is possible to do without them."

That some very valuable meteorological work is being done by our West India neighbors, the "Observaciones Magnéticus y

Meteorológicus del Real Colegio de Belen de la Compania de Jesus en la Habana" give ample evidence. The publication before us is one of a series, and gives in detail the magnetic variations, the readings of the barometer and thermometer, the tension of the aqueous vapor, the relative humidity, the velocity and direction of the wind, the amount of precipitation, the cloudiness, with the direction of motion of the upper and lower clouds. The observations are for the months of October, November and December, 1885. A general review of the weather for the whole year follows. The observed data are also graphically represented by means of curves and diagrams.

THE following is from the fifth monthly report of the Michigan State Weather Bureau, which is under the able direction of Sergeant N. B. Conger:

The percentage of verification of weather and temperature signals for the month of June is: Temperature, 87.2; weather, 83.0; temperature and weather, 85.1.

The railway weather signals were verified as follows: Detroit, Grand Haven & Milwaukee Railway, 84.3; Chicago & Grand Trunk Railway, 83.7; Port Huron & Northwestern Railway, 84.6.

The railway weather signals will be displayed after July 15th on the Michigan Central system, the Grand Rapids & Indiana Railway, and the Chicago & West Michigan Railway, arrangements having been completed and signals made for these roads. This will cover an immense tract of agricultural lands, and will give farmers and others the indications each morning for the following 24 hours. These signals are carried on the baggage cars, and are placed horizontally, and are read from the front to the rear of the car.

The appropriation for distribution of weather indications daily having become available, indications can now be telegraphed or telephoned to a limited number of towns where the weather signals will be regularly displayed, and as the U. S. Signal Service and the State service is at considerable expense to distribute these indications, they will only be issued to such towns as display the signals regularly and forward the required monthly

report to this office. All stations where this is neglected will be discontinued, as the demands for these indications are so numerous that they can only be issued to those who will comply with the existing rules of the service. All applications for indications, display of signals, or for blanks, franked envelopes for reports, etc., should be made to the director. These indications are issued to the towns displaying signals, free, but the delivery of these messages is not paid for.

The chief signal officer furnishes, when practicable, for the benefit of the general public and those industries dependent to a great extent upon weather conditions, the "Indications," which are prepared at this office daily, at one A. M., for the twenty-four hours commencing at 7 A. M. These weather forecasts are telegraphed to many Signal Service stations, railway officials, and others, and are so worded as to be readily communicated to the public by means of flags or symbols.

CURRENTS IN THE GULF OF MEXICO.—These are bitterly complained of by navigators on account of uncertainty as to direction and velocity. They are usually represented as entering the Gulf at the south, near Yucatan, and leaving it at the north, but navigators find it by no means constant. It often flows out at the south, and its velocity is extremely variable. The uncertainty with regard to it makes it always a question where a vessel running from the mouth of the Mississippi river to the north-eastern point will strike the land, and observations for position are always necessary about the time they expect to see land. The current along the east coast of Yucatan is more certain, though incorrectly represented on the maps. It is always northward, but with a varying velocity, which may reach three or four miles per hour.

BELIZE.—This city, with 8,000 or 10,000 inhabitants, and the metropolis of the east coast of Central America, is at one of the mouths of the river of the same name. It is built almost entirely of made ground, derived from ships' ballast and similar sources. It is, as a consequence, but little above high tide; in

fact unusually high tides sometimes invade the town and reach the doorways. It is backed by extensive mangrove swamps which reach several miles inland. The purity of the waters surrounding the city depends entirely on the daily change of the tide. Cellars, wells and underground interment are naturally impossible within or near the city, and it is by no means easy to get slope enough to carry off the surface water. Drinking water is entirely derived from tanks above ground in which the rain-water is stored, and one of the principal dangers threatened at all times to this city entirely surrounded by water is the lack of fresh water. The rains are abundant for nine months of the year, and with proper apparatus for collecting it there should be no lack of water. The growth of plants within the city is thoroughly tropical in its luxuriance, and it is found necessary to keep the trees thinned out to permit of free access of the winds.

Notwithstanding these apparently very unfavorable features Belize is both a clean and healthy city, and notwithstanding its latitude of about 17½ degrees, it is fairly cool. Its health and coolness are largely due to the trade-winds, which have full sweep of the place. With them and the frequent showers the temperature is not only endurable, but it is cooler than New Orleans or New York in summer. Stagnant reaches of water are prevented by a fine canal, with cemented sides, which passes through the town from north to south, cutting the river at nearly right angles, and permitting free wash to the tides. The turkey buzzards are a not unimportant feature in the sanitation of the town. They are abundant and so tame that they hop about the streets like chickens, while they are very effective scavengers. The office performed by the buzzards on land is also performed by the catfish in the shallow water, where they are surprisingly numerous and tame.

As a result, Belize is really, and contrary to prevailing ideas, a very healthful place. Rheumatism is prevalent, but fevers are by no means common. The whites of Belize have little of the sallow and languid look of settlers in the tropics and nothing of that of countries subject to dangerous fevers. Fevers

are present, but they are not generally of as dangerous a character as those of the Mississippi Valley. Occasionally, probably because of idiosyncrasies in the patient, they assume a pernicious type, which, however, is never epidemic. In the early summer of this year two such pernicious fevers resulted fatally. One case was that of a young lady just arrived from Spanish Honduras, the other a sister of charity who had lived in Belize for some years. Yellow fever has sometimes been brought to Belize, but it is never epidemic.

As to the colony of British Honduras generally, it is swampy along the coast but sandy in the interior. At the north it is low, with many extensive swamps, while it grows mountainous in the south—the Cockscomb mountains reaching an elevation of 3,000 or 4,000 feet. Notwithstanding this, the northern part is best known and was earliest settled. The southern part, along the coast, is being rapidly devoted to fruit farms, but much of the interior is still unexplored. The reason for this state of things is to be found in the fact that in early times mahogany and logwood were the principal products of the country, and they could be much more easily obtained in the more level country. It is only recently that the attention of the colony has been turned to agriculture. A detailed map of the colony is yet a desideratum. The writer saw such a map in manuscript, the work of Mr. Mitchell, the Presbyterian schoolmaster at Belize. Many of the details were derived from Mr. Mitchell's own observations, and he proposes to fill up, by his explorations, the few vacant spots of the map representing the parts which yet remain unknown.

MEMORIALS OF A HALF CENTURY.—Mr. Hubbard's interesting book contains in flowing language the observations and experiences of one who when but a lad came to Michigan more than a half century ago. The nature and scope of the work can best be seen from the headings to some of the chapters, as for instance: "Scenery of the Lakes," "A Michigan Geological Expedition in 1837," "French Habitants of Detroit," "Indians in Michigan," "The Mound-Builders in Michigan,"

"Fauna and Flora," "Wild Animals of Michigan," "Trees," "Climate of Detroit and the Lake Region," "Periodical changes in the Lake Levels, Rainfall, Temperature and Sun spots, and their relations to each other," "The Winter Season," "Spring Tide," "Our Summers," "Autumn," etc.

The 160 pages devoted to the climatology of the lake region are of interest to the meteorologist, and deserve more than a passing notice in this place. The author first explains, with the aid of charts, how the great lakes are instrumental in modifying the climate. Speaking of the eastern shore of Lake Michigan, he says: It is destined to become the most noted fruit region of the United States, having all the advantages of the climate of the Ohio, the Missouri and California, without their draw-backs.

Considerable space is devoted to the subject of precipitation, diagrams and tables, being used in the discussion. The author cannot resist the temptation of presenting a meteorological horoscope; he however, very good naturedly makes these predictions stand for what they are worth by using the following language. "Assuming that her periodicities will bring about the same average results in the future as in the past half century, I might undertake to be in some sort her interpreter of the coming events which cast their shadows before, along the pathway of a few unborn years; provided the same latitude be accorded me which was claimed by the old almanac-makers, to qualify the record with "about . . . . these . . . . . days. Premising that the sun-spot curve," etc., etc. . . . . . " Blessed be the sun-spots!" The book is well worth reading, and possesses matter of real scientific interest.

A GERMAN NEWSPAPER'S AID TO METEOROLOGY.

The fourth annual volume issued by the "Wetterwarte der Magdeburgischen Zeitung," containing the observations made at Magdeburg during the year 1885, has just come to hand.

The previous volumes have been prepared by Dr. Assmann (now of Berlin), but this one carries the name of A. W. Grützmacher as editor, and superintendent of the observatory.

In Part I there are given the tables of the tri-daily control or terminal observations arranged according to the international form.

Then follow the monthly and annual summary of these observations; the five day periods of temperature, and the mean temperature for each day at an altitude of two metres above the ground.

The daily mean temperature observed at an altitude of thirty-two metres, for the years 1881–1884, computed from three observations daily (8 A. M., 2 P. M., 8 P. M.).

For the months May–August the reductions formula is

$$\frac{\dfrac{(8\text{ A. M.} + 8\text{ P. M.})}{2} + \dfrac{(\text{max.} + \text{min.})}{2}}{2}$$

For the months September–April the formula is

$$\frac{\dfrac{8\text{ A. M.} + 8\text{ P. M.}}{2} + \dfrac{(8\text{ A. M.} + 2.\text{ P. M.} + 8\text{ P. M.})}{3}}{2}.$$

Part II contains the mean hourly air pressures arranged according to months, with the annual values; also curves showing the daily and annual period of the air pressure. Then follow the continuous barograph curves for each day of the year. For the sunshine is given, the mean hourly curves for the year and each of the four seasons; and also the amount of sunshine is given graphically for each hour of the year, with the times of sunrise and sunset for each day. The total monthly sunshine for each hour is given in minutes at the bottom of the columns.

The hourly wind force and direction is given for each hour of the year.

Part III contains the tri-daily (8, 2, 8) observations on an Arago-Davy actinometer mounted at an altitude of 1.5 metres above the ground.

Part IV gives the underground temperatures at depths of 5 metres, 3 metres and 1 metre, observed daily at 1 P. M.; and at the depths of 0.15 in., 0.05 in., 0.00 in., observed tri-daily.

Part V gives the daily temperature extremes observed on

three uncovered minimum thermometers—on the ground, in short grass, 5 cm. above the sod; also two maximum thermometers on the ground. one covered with a little earth, and the other uncovered.

In Part VI we find the temperature extremes of the surface of the ground observed on five minimum thermometers, one on a flat surface and the other four on surfaces having a slope of 45° toward the four cardinal points; also five maximum thermometers (with bulbs covered with a thin layer of earth) arranged like the minimum thermometers. Results are given from May, 1885, April, 1886. (The winter months and March are lacking.)

Part VII gives the daily observations of the highest "insolation" temperature, at an altitude of 31 metres.

Part VIII contains the evaporation in mm. as shown by a Wild evaporimeter.

Part IX contains the height of the water at the ground observed at 11:30 A. M. on each day of the year.

In the appendix Mr. Grützmacher gives an interesting comparison of the deviation, from the true mean temperature, of combinations of different hours, for the observations at Berne, Vienna, Magdeburg, Pawlowsk, Upsala. The observations used were for the year 1885, except for Magdeburg and Upsala, where the years 1886 and 1884, respectively, were used.

For the hours 8, 2, 8, he used the formula

$$\frac{\dfrac{(8\text{ A. M.} + 8\text{ P. M.})}{2} + \dfrac{(8\text{ A. M.} + 2\text{ P. M.} + 8\text{ P. M.})}{2}}{2}$$

but during May–August the formula used was

$$\frac{\dfrac{(8\text{ A. M. } 8 + 3\text{ P. M.})}{2} + \dfrac{\text{max.} + \text{min.}}{2}}{2}$$

For the hours 7, 2, 9, he used the formula

$$\frac{7\text{ A. M.} + 2\text{ P. M.} + 2 \times 9\text{ P. M.}}{4}.$$

For 6, 2, 10, the formula was

$$\frac{6 \text{ A. M.} + 2 \text{ P. M.} + 10 \text{ P. M.}}{3}.$$

For max. and min., the formula was

$$\frac{\text{max.} + \text{min.}}{2}.$$

The final mean annual corrections deduced are

	φ	8, 2, 8.	7, 2, 9.	6, 2, 10.	Max., Min.
Berne............ 1885.	47.°	+.01	—.14	+.15	—.05
Vienna............ 1885.	48.2°	+.10	—.10	+.07	—.10
Magdeburg....... 1886.	52.1°	+.02	—.16	+.11	+.12
Pawlowsk......... 1885.	59.7°	+.07	—.05	+.12	+.26
Upsala............. 1884.	59.9°	+.00	—.01	+.07	+.19
Mean...............		+.04	—.09	+.10	+.08

From this table it is seen that different latitudes require different corrections to obtain the true mean from the same hours of observation.

Tables are also given showing the times of maximum and minimum temperatures with reference to the sun's meridian passage and rising and setting.

We miss, however, from this book of eighty-eight pages, the hourly readings of temperature, rainfall, and humidity, but it could hardly be expected that we should find everything given as fully as in the reports of the few complete meteorological observatories. We judge, however, that with 1886 the temperature observations were commenced.

The contents of this volume has been mentioned in such fullness in order to show what private enterprise can do in Europe; and such an establishment as they have in Magdeburg is about what the central office of each of our State Weather Services should have. Every one of our State services ought to issue an "annual" of complete observations for at least one place within its boundaries.

F. W.

COMPARISON OF RAIN GAUGES.*

For the past eight years systematic observations of the weather have been carried on at Newburyport, Mass., and for a period of about six and one-half years of this time the records of precipitation were obtained from a gauge of the pattern then in use by the United States Signal Service as their standard. In the latter part of the year 1885, however, a conversation which the writer had with Prof. Upton, the Director of the New England Meteorological Society, led him to suspect the accuracy of this gauge—a galvanized iron affair with a turned edge and of a somewhat circular shape at the top.

Believing that these suspicions were justifiable, a new gauge was procured of the type and manufacture recommended by our Society, and, on the 12th of December (1885), observations were begun with the new gauge,—a standard "E. B. Badger & Son, No. 3." This gauge is made of copper, with a substantial brass rim so sharp at the edge that each drop falling on it will be cut and forwarded to its proper destination—the portion which would have fallen inside going into the receptacle, and the portion which was outside of the eight-inch circle being rejected. In other words, in this gauge there was no opportunity for the drop to alight on a broad rim, rest and recuperate itself there, and then, perhaps, under the benign influence of a sudden breath of wind, roll over and fall into the gauge. Again, the straight side of the new gauge is about eight inches in height above the point where the inward slope toward the interior cistern begins, thus obviating the effect of spattering in heavy rains. The old gauge, on the other hand, has a side about one and one-half inches in height,—so conveniently low that any ill-disposed drop which was inclined to be dissatisfied with the quarters it had reached in the gauge, could readily take advantage of its ability to rebound and hop out of the gauge.

Again, the new gauge is so constructed with the upper portion fitting down over the lower portion that no moisture de-

* Paper read before the New England Meteorological Society, January 18, 1887.

posited on the outside of the gauge can by any possibility run into the cistern. On the contrary, in the old gauge the upper receptacle fits into the lower one in such a manner that when particles of moisture which, by a slight inaccuracy of aim, have failed to fall into the gauge, are driven by a current of air against the outside of the upper receptacle, they may, without the slightest difficulty, float down on their way and run in, through a crevice which cannot be hermetically closed, to the lower cistern. All this may be a very good arrangement to suit the convenience of the drops of moisture, but we must conclude that it is not productive of the best results in the science of meteorology.

Immediately upon coming into possession of the new gauge the writer began a series of comparisons of the amount of precipitation collected by the two gauges in the different rain and snow storms. For a period of four months, however, it was found impracticable to carry on the observations with the gauges in close proximity to each other. They were in about equally good exposures, but being nearly fifty feet apart and differently situated with respect to a building about thirty feet distant from each location, the records obtained during that period are not regarded as entirely reliable, or especially valuable, except as in some manner confirming the results afterward obtained. Consequently, I shall not refer at present to the records obtained while the gauges were thus separated, but will proceed directly to the more important data.

On or about the 20th of April (1886), the old gauge was removed to a position about sixteen inches distant from the new one, each gauge being in a good exposure, the upper rim one foot above the ground, and that over grass.

After that time comparative measurements of the precipitation collected by both gauges were made continuously for the remainder of the year, except when prevented by some accident, or when it has been impracticable in the case of a badly drifted snow-storm to use the record of either gauge as it stood.

In these comparative measurements 25.09 inches of rain collected by the new gauge has been measured, while in the same

time the old gauge has collected 27.22 inches, or, as expressed in tabular form:

TABLE I.

Total amount collected by old gauge				27.22 in.
" " "	"	new	"	25.09 "
Excess	"	" old	"	2.13 "
Per cent. of excess over amount in new gauge				.085

This comparatively regular (as we shall see) and long continued excess clearly indicates some error in the construction of the gauge. In no instance has the amount of rain collected by the old gauge fallen below the amount in the new gauge, although several times the amount in either gauge was so small that there was no appreciable difference between them. On the other hand, an excess much greater than the average has been noted. For example, on the 12th and 13th of November the record, according to the new gauge, was 0.80 inch; by the old gauge 0.92 inch, or an excess of 15 per cent. over the new gauge.

From this large excess the percentages have ranged downward, the lowest per cent. of excess in any instance in which the whole amount of the precipitation was over one-half inch, having been recorded on the 30th of July, when the amount collected in the new gauge was 0.64 inch and in the old gauge 0.66 inch, the excess being equivalent to 3.1 per cent.

In comparing the records in different storms and the percentages of excess in each, two facts are brought strikingly to our notice: first, that a higher per cent. of excess almost invariably obtains when the precipitation is accompanied by a brisk or high wind; second, that the per cent. of excess is almost invariably lower when there is a heavy down-pour of rain with little or no wind.

Let us substantiate these statements by illustrations. To do this, I have prepared the following table, which contains a record of the amount of precipitation collected by each gauge, the per cent. of excess by the old gauge, and the maximum velocity of wind during the prevalence of the rain in each storm in which

the elements of precipitation and high wind have been co-existent:

TABLE II.

Date.	Am't col. by new gauge.	Am't col. by old gauge.	Per cent. of excess.	Max. velocity of wind.
May 8, 9......	1.61	1.78	.105	25 m. an hour.
" 26	0.06	C.06	.000	20 "
Aug. 2.........	0.16	0.17	.063	22 "
Oct. 26-28,...	0.81	0.91	.123	24 "
" 28-31...	1.97	2.23	.132	31 "
Nov. 12, 13...	0.80	0.92	.150	30 "
" 25.......	0.39	0.45	.154	21 "
Dec. 1.........	0.28	0.30	.071	19 "
" 12, 13...	0.17	0.20	.177	21 "
" 30, Jan. 2.*	1.16	1.24	.069	21 "
Sums..........	7.41	8.26		
Mean..........			.115	

* Precipitation partly in the form of snow.

To this table let me add, without special emphasis, but merely to carry out the illustration, the records of two storms that occurred while the gauges were in different locations, as described above.

TABLE III.

Date.	Am't Collected by New Gauge.	Am't Collected by Old Gauge.	Per cent. of excess.	Max. Vel. of wind.
March 20-21.	1.37	1.58	.153	29 m.
April 5-7......	1.73	2.22	.283	36 m.

In view of these facts is it not reasonable to suppose that the precipitation, much of which often is in such storms, and actually was in the instances recorded, in the form of mist, was driven by the force of the wind against the outside of the gauges, where it collected and trickled down, and, in the case of the old gauge, made its way through to the interior of the cistern at its junction with the upper receptacle, thus increasing the amount of precipitation registered?

Again, recurring to my second statement made above,—that the per cent. of excess was lower in case of heavy down-pours of rain with little or no wind,—I introduce the annexed table showing, as before, the amount of precipitation in each gauge and the per cent. of excess,—together with the duration of the rain in hours, from which it can be readily seen how heavy the rainfall was.

TABLE IV.

Date.	New Gauge.	Old Gauge.	Per cent. of excess.	Duration in hours.
May 30	0.34	0.36	.059	3/4
July 15	0.56	0.61	.089	1 1/4
July 16	0.59	0.63	.068	3
July 26	0.14	0.15	.071	3/4
July 27	0.48	0.51	.063	1
July 27	0.34	0.37	.088	1 1/4
July 30	0.64	0.66	.031	1
July 30	0.10	0.11	.100	1
August 2	0.16	0.17	.063	1/4
August 5, 6	0.32	0.34	.063	5 1/2
August 7, 8	0.55	0.58	.055	9
August 16, 17	0.36	0.39	.083	4 3/4
August 30	0.11	0.11	.000	1 1/2
August 31	0.89	0.96	.079	5 3/4
September 19	0.23	0.25	.087	1 1/2
November 6, 7	1.02	1.09	.069	10
November 17, 18	1.17	1.27	.085	20
December 1	0.27	0.29	.074	4
December 24, 25	0.94	1.03	.096	7
Sums	9.21	9.88		
Mean			.073	

Thus it appears that in the case of rain falling during a high wind the excess amounted to 11.5 per cent., while during the heavy falls of rain, unaccompanied by high wind, the excess averaged only 7.3 per cent., or a difference of over four per cent. according to the different circumstances.

This small excess in heavy falls of rain leads us to the legitimate conclusion that the drops striking with considerable force the shallow receptacle in the old gauge were broken by the force of the impact and spattered out to a small extent, thus lessening the deposit in the cistern.

In the case of precipitation in the form of snow very few comparative measurements have been made,—on account of the utter worthlessness and inadequacy of the old gauge to collect the snow except under the circumstances of a very light fall and the absence of wind. Under other circumstances the shallowness of the upper receptacle of the gauge is very efficient in vitiating the records, for if the fall be of more than three inches the snow is so heaped up in the gauge and over the top that it will fall off at the sides and begin to assume a conical shape, and if there be enough wind to stir the fallen snow it can be very easily blown out of the receptacle and lost.

In order to eliminate any error that might have arisen from any inequality in the diameter of the cisterns of the two gauges,

I also made a series of comparisons of the measurement of a given amount of water, first in the cistern of one gauge and then in that of the other. And to remove from this comparison the possible error that might accrue from the moisture adhering to the cistern in which it was first measured, I carefully reversed the operation each time, now measuring the water first in the new cistern before measuring it in the old, and then measuring the next amount in the old before measuring it in the cistern of the new gauge.

Ten such comparative measurements were made,—the results of which were as follows:

TABLE V.

Amount in New Gauge.	Amount in Old Gauge.	Per cent. of Excess.
.170 inch.	.170 inch.	.000
.285 "	.287 "	.007
.427 "	.432 "	.012
.543 "	.550 "	.013
.667 "	.676 "	.013
.752 "	.760 "	.011
.845 "	.855 "	.012
.946 "	.956 "	.011
1.352 "	1.365 "	.010
1.740 "	1.754 "	.008
7.727 "	7.805 "	.0101

There was thus a very nearly constant excess in the measurement in the cistern of the old gauge, amounting to almost exactly one per cent. of the amount recorded in the new one.

Finally, as I was in possession of two measuring sticks,—one of which had been in use many years with the old gauge, while the other had been recently received with the new gauge,—I made a series of measurements with both sticks in order to ascertain if possible if there was any error due to the different capillarities of the sticks. The old stick had evidently been covered with shellac a long time before coming into my possession, and appeared, to the eye, to give a very accurate measurement, free from any capillary error. The new stick was in its native condition and was somewhat harder to wet, there being always a slight capillary depression visible.

Eighteen comparisons were made with varying depths of water, and the average difference was found to be about .004 (or four-tenths of one per cent.)

Without attempting to make any further deductions, the above facts are respectfully presented in the hope that they may prove to be of some practical value in the progress of the science of meteorology.

FRANCIS V. PIKE.

NEWBURYPORT, MASS., June, 1887.

THE DEUTSCHE SEEWARTE.

(GERMAN MARINE OBSERVATORY.)

Each of the German States has its own Meteorological organization, but the "Seewarte" is the national meteorological observatory. This institution, located at Hamburg, has now been in existence for a little more than ten years. During this period it has issued to the scientific public many valuable contributions to the subjects with which it has to deal. For the first five years the force of workers at this "Central Office" found quarters in the Seaman's House at Hamburg, but since 1881 the present building has been occupied.

In the various reports of Director Neumayer we find glimpses of the arrangement of the observatory and descriptions of some of the instruments in use. We have now before us a volume* which will be of the greatest service to all practical meteorologists and those engaged in any of the numerous branches of work undertaken by the Seewarte.

Dr. Neumayer has given a complete set of illustrations of the arrangement of this new building, and of the apparatus, such as we have not seen for a scientific institution. He gives 29 pages of plates which show the minutest details of buildings and instruments, with a short general description of each plate.

The observatory is situated in a park, and on a bluff overlooking the Elbe River, and has a horizon extending far across the

*Aus dem Archiv der Deutschen Seewarte. VII Jahrgang, 1884. Hamburg, 1886 (Price about 20 M.)

flat surrounding country. This bluff is perhaps sixty or seventy feet high, and descends abruptly almost to the river bank.

The structure probably cost about $150,000, and is the finest in the world devoted to meteorological and allied pursuits. The internal arrangement is in the form of a hollow square with a court in this center which has a glass roof for the purpose of lighting it from above.

This court is surrounded by open corridors on each floor, by means of which we gain access to the rooms, all of which are on the outside and are therefore light and pleasant offices.

The work of this observatory is divided into four divisions, three of which are in this building, namely, those which are devoted to the meteorology of the oceans; investigation of nautical and meteorological instruments; and storm warnings, coast meteorology and general weather investigations. The fourth department, that for the testing of chronometers, is located in the astronomical observatory which lies near.

In the towers (at the four corners) are mounted a universal instrument, a transit instrument, a wind register, and an apparatus for investigating the errors of sextants.

In the open court, forming the center of the building, there is a Combe's rotation apparatus which is used for the purpose of testing anemometers, and also has an attachment for investigating the effect of a ships-motion on the rate of chronometers.

There is an underground magnetic observatory in front of the building, which is connected with the main building by a subterranean passage.

The library, which occupies a portion of the second floor, is very complete, and is conveniently arranged. Here we find the library of the celebrated Dové. A long room under the library, on the first floor, is used as an exhibition room for all kinds of meteorological and nautical apparatus and models. The standard and self-registering apparatus are in the basement.

The weather predictions are issued twice daily for Germany, and the storm warnings for the German coast are sent out from the predictions division; this observatory is also one of the harbor display stations for storm signals.

Director Neumayer is certainly to be congratulated on his success in building up such an institution and bringing about him the men he has obtained to assist him in carrying on his work.

For ten years Hamburg has been the center of meteorological activity for Germany, and the work of Neumayer, Köppen, Van Bebber, Sprung and others, has given the Seewarte a high reputation, which has been lately increased by the issue of the *Meteorologische Zeitschrift*, one of the editors of which is the "Meteorologist" of the Seewarte.

How formidable a rival the newly re-organized Prussian Meteorological Institute, at Berlin, will be, with such men as Von Bezold, Sprung, Hellmann and Assmann, remains yet to be seen. This new meteorological center at the German metropolis, and in connection with the University, will undoubtedly exert a powerful influence on the future study of meteorology.

FRANK WALDO.

TORNADOES.

The recent destructive storms in the west have greatly increased the interest felt in the subject of tornadoes, and questions are rife concerning their origin, development and movement. It is important that we have a clear apprehension of the terms that ought to be used, as we find nearly all persons, including governors of states and editors of newspapers, especially in the west, laboring under grave misapprehension. The term cyclone is the most abused of all. This was first applied by Piddington to West India storms, and should not be used elsewhere. Unfortunately, meteorologists, especially in Europe, have applied the term cyclone to all storms having winds blowing spirally toward a low centre, commonly designated as "low" on our weather maps. There is the utmost need of a careful distinction being made, by using either a descriptive term, as West India cyclone, temperate region cyclone, etc., or else a new general term for the class, such as "low" or "low area" or "helicone," etc.

The West India cyclone is characterized by a sudden and great fall in barometric pressure, very high winds blowing spirally inward, usually accompanied by heavy rain and less frequently by electric displays. They have never occurred nearer than 10° to the equator, and generally have at first a slight motion to the westward, then, curving, move up the Atlantic coast and frequently form the temperate region cyclones, which are spread out over a great area, and much less intense in all their action.

Other terms may be defined as follows: A thunder storm is a storm displaying electric action, the thunder being caused, probably, by the sudden blow or stroke, as it were, of the electricity upon the air. A typical thunder-storm, and one frequently experienced in the east, may be described as follows: Dark clouds appear in the west on a hot, sultry afternoon in summer; the wind is gentle from the south or the air is calm; in the west, some time before the first thunder, one sees frequent flashes of lightning, and an appearance as of rain falling in sheets. At last there appears an enormous cloud of dust rising to a height of 200 feet or more, and advancing rapidly from the west toward the observer; by watching a wind vane carefully, it will be found that, in an instant, this is jerked into the west by a high wind, before which, frequently, the thunder is heard, and often the first rain falls. By watching an aneroid barometer, gently tapping the glass face every two minutes, it will be found that while it has been falling all day perhaps, the fall is now suddenly arrested, and it begins an upward turn, frequently rising 2 mm. (.08 in.) before the centre has passed, after which the pressure falls and reaches the same point as before the storm. By counting the number of seconds between flash and sound, and allowing 1,100 feet per second for the velocity of sound, it will be found that the storm is approaching, and passing away at a very great speed, 50, 60, or even 70 miles per hour. The rain cools the air, and after the storm has passed, the sun comes out, and the wind falls back to the south as before.

Another storm frequently experienced is a hurricane. This is a straight line wind of great violence. The best example of a

moderate hurricane, for those living in the east, is the high wind, just preceding a heavy thunder-storm, as described above. It is highly probable that four-fifths of the destructive storms of the west are of this class.

A tornado, as applied to our western storms, may be best described as a hurricane, having in it a funnel-shaped cloud, possessing a gyratory motion, which is much more destructive in its action than the hurricane proper. It is always attended by the most violent electric displays; this latter characteristic has been specially marked in the recent Ohio storms, as one could not help seeing while reading any of the accounts. Nothing can stand before its violence, and it is frequently accompanied by torrents of rain, and by heavy hail falls. While it is extremely local in its action, yet the same tornado has been known to dip down, rise and dip, again and again, clear across a State.

What gives rise to this concentration of nature's forces, and this veritable besom of destruction? We can do no better, perhaps, than to quote some of the writings on this subject. One writer offers a theory as follows:

"When, on account of greater heat, or a greater amount of aqueous vapor, the atmosphere at any place becomes more rare than the surrounding portion, it ascends, and the surrounding heavier atmosphere flows in below, to supply its place, while a counter-current is consequently produced above. As the lower strata of atmosphere generally contain a certain quantity of aqueous vapor, which is condensed after arising to a certain hight, and forms clouds and rain, the caloric given out in the condensation, in accordance with Espy's theory, produces a still greater rarefaction, and doubtless adds very much to the disturbance of equilibrium, and to the motive power of storms."

Another writer says:

"Suppose a mass of warm, moist southerly wind has pushed itself below a colder northwesterly stratum. The warm wind, feeling about for a point of escape through its cold cover, soon makes or finds a vent where it can drain away upward, and then the entire warm mass, even a mile or more in diameter, and often more than one thousand feet in thickness, begins a rotary motion, rises at the centre and passes away."

We give one more citation from still another writer:

"The inward rush of winds toward a depressed centre is the cause of our thunder-storms, which are only infant cyclones and tornadoes. The

whole country for 500 miles square, from the Missouri to the Ohio valley, is covered with a mass of warm, moist air flowing northward. At numerous spots in this region this acquires an upward motion, thereby giving rise to local upward currents of air, which cool rapidly as they rise. The cooling is a mechanical result of the expansion of the rising air, and very soon a temperature is reached low enough to condense clouds from the hitherto invisible moisture. With the formation of clouds, the tendency to rise increases, so that, in fact, an upward suction is experienced under the cloud, and more air is drawn in from all sides to feed this suction."

"Whatever causes a sudden uprush of moist air contributes to the formation of the cloud or the tornado. Hills or low mountains are very effective. But it is equally important to consider the cool, dry air that flows from the north toward a low centre, and becomes a west wind, as it turns around the low, runs into the mass of warm, moist air coming from the south, and being denser, underruns and lifts up this warm air, and is in many cases more effective than a mountain in starting the formation of a cloud and local storm."

These quotations will suffice to give an idea of the general fundamental theories held by many as to the origin of these violent storms. It is very evident, that if we transfer the seat of violent action from the earth to the air above it, we can only with great difficulty prove or disprove any theories advanced; we may, however, be able to determine from observation, how far some of the theories can satisfy the conditions. It seems difficult to comprehend how there can be any rapid interchange of great masses of air of different densities. In fact, Dr. Hann, of Vienna, has shown, that if there is any interchange of air in different strata it can only be by insensible degrees between those lying near each other. Moreover, careful computations have shown, that even if there were such interchange, no sudden and great liberation of energy would ensue. If we consider the question of the action of warm southerly meeting cooler northerly winds, we find that in the region of tornado action there are no northerly winds at all, and as it has been shown that the winds above the earth's surface, around a storm centre, follow the same laws as those below, we must conclude that this effect is inappreciable. One very important fact, in regard to the effect of the sun's heat, seems to have been overlooked. We

would naturally expect that, if the sun's heat were directly an exciting cause, tornadoes would begin at about the time when the heat was greatest, and would gradually follow the sun from the east toward the west; whereas, we find that just the reverse is true. Tornado action usually begins at 2 or 3 P. M., and works gradually eastward; this was shown very markedly in the Ohio tornadoes of May 12, 1886, and has been repeatedly noted in other cases, especially in the tornadoes of May 30, 1879, as described in Professional papers of the Signal Service, No. IV. But all the above considerations against the generally accepted theories fade into insignificance, when compared with the following. The generation of a tornado, as usually explained, absolutely demands an enormous diminution of pressure at the centre, precisely as in the case of the West India cyclone. Now, while we have thousands of observations at sea, where barometers are never stationary, and where they are necessarily very far apart, indicating a sudden and rapid fall in pressure on the approach of a cyclone, yet we have not a single observation on land showing any fall on the approach of a tornado, but we have several showing an undoubted rise.

The time has not yet come for a complete explanation of the phenomena in question, but it may be said that as our knowledge of the conditions immediately surrounding tornado action increases, we are enabled more and more to determine what causes are *not* influential in that action, and we may hope ultimately to collect together a sufficient number of facts for a satisfactory solution of the problem.

It is largely conceded to-day that a tornado is the most intense development of a thunder-storm. If this be so, we have before us a grand field for investigation; moreover, these storms are of so frequent occurrence that there is no necessity of waiting for observations till a tornado comes, which, when it does come, so terrifies the beholder that he forgets all else, save flight for safety. Taking up this question of thunder-storms, then, we find that: 1st. The pressure invariably increases. Repeated observations on the passage of a storm, as well as numberless barograph registers, have shown the above fact, whenever the

storm passed directly over the barometer. 2d. In these storms the motion is plainly downward and outward; this is shown by the wind. A remarkable instance of this is to be found in the storm of July 21, 1885, through southern New England, described by Mr. Davis, in *Science*. In that case the wind, which had been gentle all the morning, suddenly came from the west at the rate of 40 miles per hour. That such a wind could have been caused by air flowing out from under a downrush of rain drops, as held by some, is incredible. 3d. The region most favorable for thunder-storm action is situated in the southeast quadrant of a low pressure area (helicone) and 400 to 600 miles from its centre. 4th. An abnormally high temperature is conducive to their development. 5th. They frequently begin at a point in the country, about 400 miles from the helicone centre, at 2 or 3 P. M., and gradually move eastward at a velocity more than double that of the fostering helicone; the action continues till about midnight, thus gaining on the helicone, but the next day some of the ground is again gone over by the thunder-storms, so that the two keep constant company. 6th. The tracks are rather narrow; frequently blue sky or stars appear to observers only three or four miles from where a tornado is raging. 7th. Their course is almost invariably from west to east.

We have yet to discover the connection between the sun's heat and these electric displays, the reason for their motion in such narrow strips, their connection with each other, and with the helicone, etc., etc. This paper is already too long, or some attempt might be made to explain various interesting facts connected with tornadoes, such as the apparent bursting of houses, stripping fowls of feathers, carrying heavy objects up in the air, destroying only one of two frail structures exposed exactly alike and side by side, etc., etc.

I may add that one of the most important of these views had been developed by M. Faye, of Paris, some years ago, namely, that in all water spouts, cyclones and storms in general, there is a downward motion of the air. My own work has been done entirely independent of his, and I by no means agree with him in carrying this downward motion outside of thunder-storms

and their congeners, I hold that the uprush in the centre of a helicone is very doubtful, that it is rather a swirl in the air, very much the same as a whirlpool in a running stream, and without much, if any, upward or downward motion.

H. ALLEN.

May, 1886.

RELATION OF THE PRESSURE TO THE VELOCITY OF THE WIND.

The formula used by Mr. Rotch in the last number of this journal for reducing wind-pressure to velocity is one which seems to have come down from a preceding century, and is undoubtedly very erroneous. But as it is still used by both English and American engineers and meteorologists, it is not surprising that it should be adopted by Mr. Rotch. Putting p for the pressure in pounds on a square foot of surface, exposed normally to the direction of the wind, and v for the velocity in miles per hour, this formula is

$$p = 0.005\, v^2 \qquad (1)$$

Or, as usually expressed verbally, $\frac{1}{200}$ of the square of the velocity is the pressure in pounds upon a square foot. The very fact that the denominator is given in even hundreds makes it very suspicious that it is only a very rough first approximation, adopted for convenience. And this simple formula is used at all altitudes and for all temperatures of the air, without regard to the varying densities of the air depending upon these circumstances.

The true theoretical formula is, (*Recent Advances in Met.*, *p. 302*):

$$p = \frac{0.002698\, v^2}{1 + .004t} \cdot \frac{P}{P_0} \qquad (2)$$

in which, in addition to the notation above, P_0 is the standard barometric pressure, 760 mm., P is the pressure at the station of observation, and t is the temperature on the centigrade scale. By theoretical formula is meant the formula which would hold in case of no viscosity of the air.

For an average temperature, say 15° C. and air of the stand-

ard pressure of 760 mm., this formula becomes

(3) $$p = 0.00255\, v^2$$

Comparing now (3) with (1) we get for the ratio between the two constants in the formula

$$0.00255 : 0.005 = 1 : 1.96.$$

"The following relations have been obtained between the theoretical and the observed force of the wind upon a square foot of surface: Mariotte, 1 : 1.73; DeBorda, 1 : 1.66; Rouse, 1 : 1.90; Hutton, 1 : 1.243; Woltman, 1.19. Of these the last is considered the most reliable, and those of Rouse and Mariotte the least." (*Gehler's Physicalische Worterbuch, Band X, Part II, p. 2076*).

It is seen that the ratio obtained by Rouse, 1.90, is very nearly that between (1) and (3) above, upon the hypothesis of a temperature of 15° C. when Rouse's experiments were made, and that the temperature was taken into account in his comparison of the theoretical and experimental formula, which is very doubtful. But, however that may be, the formula still pretty generally used has, without much doubt, been based upon Rouse's experiments, the very ones which, in the extract above, are considered the least reliable.

The following formula, adapted here to English measures, has been obtained experimentally, somewhat recently, by Hagen: (*Messung des Widerstandes, den Planscheiben erfahren wenn sie in normaler Richtung gegen ihre Ebenen durch die Luft bewegt werden:* 1874).

(4) $$p = (0.00289 + 0.0001395\, u)\, v^2 A,$$

in which A is the area of the surface in square feet, and u the perimeter in feet. This is for the standard barometric pressure of 760 mm., but no account seems to have been taken of the temperature.

We have in the case in which A is a square foot, $u = 4$, and the formula then becomes

(5) $$p = 0.00345\, v^2.$$

Comparing now (3) with (5), supposing that Hagen's experi-

ments were made at a temperature of 15° C., a comfortable working temperature, we get

$$0.00255 : 0.00345 = 1 : 1.35$$

for the relation between the theoretical and Hagen's experimental constant, which is very nearly the average of those of De Borda, Hutton, and Woltman above.

But the form of Hagen's formula cannot possibly be correct, for it makes the part of the effect depending upon the viscosity of the air, at least for large plates, very nearly as the cube of the linear dimension of the plate, or as u into A, for which there does not seem to be any reason in theory, and the range in the dimensions of his plates, from two to six inches square, was not sufficient to determine the law from experiment. Hagen's formula is perhaps very nearly correct for the average of his plates, say five inches square, but when extended to a plate twelve inches square, by the law of the formula, it undoubtedly gives a constant too large. For instance, suppose we had a plate ten feet square, then (4) becomes, since u then would be 40,

$$p = 0.00847\, v^2 A. \tag{6}$$

The effect of the viscosity of the air, therefore, in this case would be to increase the pressure nearly 3.5 times that of the theoretical pressure in case of no viscosity. The application in this case leading to so great an absurdity, it is not safe to extend the formula from a plate of 5 inches square to one a foot square.

It is much to be desired that a long series of very accurate experiments should be made on this subject, both with plates of the same figure, but with a large range of areas, and also with plates of the same area, but with great diversities of figure and extent of perimeter.

In the case of a plate 5 inches square u in (4) becomes 20 inches, equal 1.667 feet, and with this value (4) gives,

$$p = 0.00312\, v^2 A. \tag{7}$$

Comparing now (3) with (7) we get

$$0.00255 : 0.00312 = 1 : 1.224.$$

This ratio falls between those of Hutton and Woltman, but is

still a little greater than that of Woltman, which is considered the most reliable in the extract above from Gehler's Wörterbuch.

That the true ratio is at least as small as this is somewhat confirmed by the results deduced by Loomis from Newton's experiments with the times of falling of hollow glass globes and of bladders with small weights attached, from which it appears that the experimental resistance differs but little from the theoretical, though there is considerable uncertainty in these experiments with regard to the exact diameters of the globes, and besides no account seems to have been taken of either barometric pressure or of temperature. ("Recent Advances in Meteorology," p. 305.)

Assuming that this latter is the true ratio between the theoretical and experimental constant, instead of 1.96, as in the case of the formula used by Mr. Rotch, then the velocities given by Mr. Rotch deduced from his pressures, must be multiplied by the $\sqrt{.00312 : .005} = 1.27$, that is, they must be increased by more than the fourth part.

But there is another consideration which comes in in Mr. Rotch's comparisons, if the wind velocities were obtained from a Robinson anemometer of the Kew pattern, and the reductions, as usual, were made by the constant 3. It has been well ascertained by two series of experiments, the results of which agree very satisfactorily, that this constant is about one-fourth too large, except for low wind velocities. Increasing, therefore, the first column of Mr. Rotch's velocities by one-fourth or more, and diminishing the last one by one-fourth part, the differences will become very great, it would seem rather too great; but still, considering the great unsteadiness of the wind, the maximum velocity during five minutes must generally be very much greater than the average for this time.

In conclusion, when are the first crude constants of the wind pressure and anemometer formulæ, based upon a very few rough experiments, to be laid aside, and the much more accurate ones, based upon more recent and much more accurate experiments, to be adopted? The constant based upon Rouse's experiments,

or at least one which is very nearly conformable with them, is still pretty generally used, notwithstanding it is one of extreme value, differing widely from all more recent determinations. Judging of the future by the past, we cannot hope that the true anemometer constant of reduction of wind velocities will come into use before the latter part of the next century. So far as my reading and recollection extend, meteorologists have not even begun to consider yet whether the reductions by the true instead of the false constant would be desirable.

WILLIAM FERREL.

KANSAS CITY, MO., June 5.

SELECTIONS.

TEMPERATURES AT WHICH DIFFERENCES BETWEEN MERCURIAL AND AIR THERMOMETERS ARE GREATEST.*

[CONCLUDED.]

When a thermometer is put in ice this is what happens: The column falls rapidly at first, then more slowly. Presently it becomes stationary; finally it begins to rise. Fifteen minutes after the thermometer reaches its lowest reading this rise is about 0.°01. It is best in observing the freezing point of a thermometer to put it in ice thoroughly saturated with water. The ice should be contained in a vessel from which the water cannot flow off. A thermometer put in ice in this condition takes on the temperature of 0° more quickly than if put in dry ice containing a good deal of air. This method of observing the freezing point was introduced by Baudin of Paris.

There is another correction to a normal thermometer which is little known and rarely applied. Let:

V = volume of bulb at 0°.

v = volume of tube from 0° to 100° at temperature 0°.

β = coefficient of cubical expansion of glass.

γ = coefficient of expansion of mercury.

* Thomas Russell in the *Bulletin of the Phil. Soc.* of Washinhton, Vol. IX, pp. 25-32.

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T = thermometer-reading corrected for calibration, etc.
t = true temperature.

A consideration of the construction of the thermometer leads to this equation:

$$V(1 + \beta t) + v(1 + \beta t)\frac{T}{100} = V(1 + \gamma t). \qquad (1)$$

The volume of the bulb at $t°$, plus the volume of that part of the tube corresponding to the thermometer-reading, is equal to the volume of the mercury at $t°$. For $t = 100$ the question becomes:

$$V(1 + \beta 100) + v(1 + \beta 100) = V(1 + \gamma 100). \qquad (2)$$

Eliminating $\frac{v}{V}$ from (2) by means of its value found from (1) we have:

$$T = t.\frac{1 + 100\beta}{1 + t\beta} \qquad (3)$$

Taking as the coefficient of cubical expansion of glass, β, the quantity 0.000026, the following values are found for $T - t$, for the various readings of the thermometer from $-40°$ to $+100°$.

T	$T-t$
°C.	°C.
− 40.	− 0.145
− 20.	− 0.062
0.	0.000
+ 20.	+ 0.042
40.	+ 0.062
50.	+ 0.065
60.	+ 0.062
80.	+ 0.042
100.	0.000

These are known as the Poggendorf corrections. They are due to the capacity of the tube from the zero to the one-hundred degree mark, being different at different temperatures.

In the following table are shown the results of the comparisons of a certain mercurial thermometer, Tounelot No. 4207, with the air-thermometer:

TOUNELOT NO. 4207.

Scale reading.	Correction as a normal thermometer.	Correction to reduce to the air-thermometer.	Differences.
° C.	° C.	° C.	° C.
0.0	0.00	0.00	0.00
5.6	+ 0.05	+ 0.01	+ 0.04
11.1	+ 0.08	0.00	+ 0.08
16.1	+ 0.10	+ 0.02	+ 0.08
22.2	+ 0.15	+ 0.05	+ 0.10
25.2	+ 0.16	+ 0.07	+ 0.09
30.1	+ 0.20	+ 0.09	+ 0.11
35.4	+ 0.22	+ 0.10	+ 0.12
40.4	+ 0.25	+ 0.12	+ 0.13
45.1	+ 0.25	+ 0.16	+ 0.09
50.1	+ 0.24	+ 0.15	+ 0.09
52.7	+ 0.24	+ 0.16	+ 0.08
55.2	+ 0.24	+ 0.18	+ 0.06

If it be supposed that these differences are due to sensible terms in the expansion of glass and mercury dependent on the squares of the temperatures, an equation can be derived which will show that the maximum difference must be at 50°. But this is not so; the greatest difference is at about 40°. This agrees with what has been found by others. Rowland at Baltimore found the greatest difference at 40° to 45°; Mills in England found it at 35°, and Grunmach in Berlin at 30°.

Forming a theory of the differences on the supposition that they depend on the third powers of the temperatures as well as the squares, equation (4) is obtained, which gives the relation between the thermometer-reading, T, and the true temperature, t.

$$T = t.\frac{1+\beta_1 100}{1+\beta_1 t}\cdot\frac{1+\dfrac{\gamma_2-\beta_2}{\gamma_1-\beta_1}t+\dfrac{\gamma_3-\beta_3}{\gamma_1-\beta_1}t^2}{1+\dfrac{\gamma_2-\beta_2}{\gamma_1-\beta_1}100+\dfrac{\gamma_3-\beta_3}{\gamma_1-\beta_1}(100)^2}\cdot \qquad (4)$$

This is only approximate. The effects of the second and third powers of the temperatures in changing the capacity of the tube from 0° to 100° are neglected. The capacity of the tube is only $\frac{1}{25}$ part of that of the bulb.

β_1, β_2, β_3 are the coefficients of expansion for glass for the first, second, and third powers of the temperature. γ_1, γ_2, γ_3 are the same for mercury.

To make an adjustment of the differences between the mercurial and air-thermometers equation (4) can be put in the form

$$(100t - t^2)x + (10000t - t^3)y + 0.000026t^2 - 0.0026t + \Delta = 0 \qquad (5)$$

in which

$$x = \frac{\gamma_2 - \beta_2}{\gamma_1 - \beta_1},\ y = \frac{\gamma_3 - \beta_3}{\gamma_1 - \beta_1} \text{ and } \Delta = T - t.$$

This is less approximate than (4) but still sufficiently rigorous for the purpose intended.

Forming observation-equations on this model with the observed differences Δ, as the absolute terms, and solving by the method of least squares, the values of x and y are found to be

$$x = -\ 0.0001391$$
$$y = +\ 0.000000863$$

Substituting these in (5) it becomes

$$-\ 0.00788t + 0.000165t^2 - 0.000000863t^3 + \Delta = 0. \qquad (6)$$

Differentiating (6) with respect to t and Δ, and putting $\frac{dt}{d\Delta} = 0$, the following quadratic-equation is found

$$0.000002589t^2 - 0.000330t + 0.00788 = 0, \qquad (7)$$

the solution of which gives for the temperatures at which the differences between the mercurial and air-thermometer are greatest $t = 31.8$ and $t = 95.8$. To find the temperatures at which the mercurial and air-thermometer agree, put $\Delta = 0$ in (6); the values of t that then satisfy the equation are $t = 0$, $t = 100$, and $t = 91$.

At 32° the mercurial thermometer reads higher than the air-thermometer, at 96°, it reads lower. A curve representing the differences has the following form:

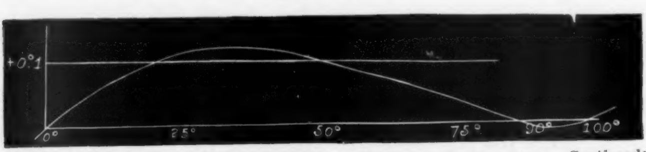

FIGURE 1.—T 4207 *minus* Air-thermometer. Abscissas = Temperatures. Centigrade. Ordinates = Differences.

This agrees with what has been observed by Dr. Grunmach of the Berlin Aichungs Commission. He found the maximum difference on a certain thermometer to be + 0.°12 at 29.°8, and another secondary maximum of — 0.°04 at 82°.

A slight change in the values of x and y will make a large change in the position of the secondary maximum. For another thermometer investigated at the Signal Office this point was found to be at 130°.

The values of x and y can be analyzed still further to ascertain whether consistent with known physical properties of glass and mercury.

Taking Broch's values for the expansion of mercury, which are based on a re-reduction of Regnault's observations, it is found, adapting the figures to the notation used here, that:

$$\gamma_1 = +\ 0.000181792$$
$$\gamma_2 = +\ 0.000000000175$$
$$\gamma_3 = +\ 0.000000000035116$$

Substituting these values of γ_1 and γ_2 in the equations

$$x = \frac{\gamma_2 - \beta_2}{\gamma_1 - \beta_1},\quad y = \frac{\gamma_3 - \beta_3}{\gamma_1 - \beta_1}$$

and taking $\beta = 0.000026$ we get

$$\beta_2 = +\ 0.000000021859$$
$$\beta_3 = +\ 0.000000000099512$$

The linear coefficient of expansion of a specimen of glass, such as is used in barometer-tubes and thermometers, has been very carefully determined by Dr. Benoit of the International Bureau of Weights and Measures. Deriving from this the cubical coefficient, in the notation used here, we have Dr. Benoit's values

$$\beta_1 = +\ 0.0000252$$
$$\beta_2 = +\ 0.0000000144$$

It will thus be seen that there is a good agreement between the two values of β_2 found by the two different processes.

THE FŒHN.*

A study of the effect that mountains produce on the winds that pass over their passes opens one of the most instructive chapters in modern meteorology, deserving a much more detailed treatment than can be given to it here. We may first describe the phenomena involved, and then briefly consider the history of their explanation.

First in Switzerland and afterwards in other mountainous countries, the attention of meteorologists was called to the occurrence, especially in winter time, of a warm, or even hot, dry wind, blowing briskly down the valleys from the high, cold passes. The Swiss name for such a wind is "Fœhn," said to be derived from the old Latin name Favonius. Various local names are used in other countries, as will be seen below; but with the present understanding of the origin of the wind, all examples of it may be included under the Swiss term, which has now become of generic value. When the Fœhn blows, it is common to see a bank of dark clouds over the pass at the head of the valley from which the wind descends. Under its effects the snow-fields melt away, and the streams rise in freshets. Desor tells how at such times the Swiss peasants, having grass to cut on the upper pastures, will hasten there to work even at night, knowing that a single day of Fœhn wind will dry the hay completely. The danger of fires in the villages is then so great that after learning wisdom by experience, the town of Glarus prohibited smoking in the streets during the blowing of the Fœhn, and ordered extra precautions in regard to house fires. The relation of the high temperature and low relative humidity of the valley Fœhn to the low temperature and high relative humidity characteristic of the mountain passes from which it descends, appear paradoxical at first sight, and have given rise to many theories and long discussion; and the history of the progress towards what may now be confidently called the true explanation of the wind presents an epitome of the transition from the old to the new school of meteorology.

Among the first explanations suggested for the Swiss Fœhn,

* From "Mountain Meteorology."

we naturally find one that gives it an origin in the Sahara. The great desert of northern Africa was regarded as a storehouse of all that is hot and dry, and winds blowing out from it were known to maintain their torrid characteristics even across the Mediterranean, giving southern Italy and Sicily the dry, enervating, dust-laden Sirocco, and Spain the corresponding Leveche, under whose influence a temperature of above 110° F. has been recorded at midnight! (To avoid confusion, it may be noted that the name Sirocco is applied in Italy also to a moist, cloudy, rain-bearing wind, and that the Spanish Leveche is often improperly called the Solano.) It was but natural to suppose that an extension of the dry Sirocco over the Alps would produce the Fœhn, as long as the physical changes in ascending and descending currents were overlooked or misunderstood.

Desor and Escher von der Linth were prominent among the advocates of this old theory. They, together with Martins, of Montpelier, made an expedition to the Algerian Sahara, and returned convinced not only that the Fœhn came ready made from the desert, but that the submergence of the desert in recently past geological time must have extinguished the Fœhn, and thus allowed the accumulation of snow on the Alps even to the production of the glacial period (Aus Sahara und Atlas, 1865, 40; "Die Beziehungen des Föhns zur Afrikanischen Wüste," Jahrb. Schw. Alpen-club, 1865, ii, 407–422). Apart from other objections to this theory, it is now known that only a small part of the Sahara was under water when Switzerland was under ice, and also that the still debated cause of the glacial period was not locally applied to the Alps alone, but was active over large and distant parts of the earth. Escher's statement may be found in a geological lecture delivered by him in Zurich in 1852 (Zwei geol. Vorträge, Zurich, 1852, 24).

The objections urged by Dove against the African origin of the Fœhn are characteristic of the time when the local cyclonic circulation of the wind was unknown. He maintained that, on account of the deflective effect of the earth's rotation, an equatorial current moving from the Sahara could not reach southern Europe, but must fall on Asia Minor or Persia, and therefore

that a warm wind on the Alps must be of western Atlantic origin; in other words, he saw only poleward baric gradients as a cause of winds, and looked on nearly all winds as members of the general or planetary circulation of the atmosphere. As an oceanic origin of the Fœhn wind would imply a high degree of humidity, and as rain commonly fell on the south of the Alps when the Fœhn was reported in the northern valleys, Dove went so far as to doubt the dryness that makes so characteristic part of its description by all local observers; and this gave rise to a serious controversy with the Swiss meteorologists.

Dove's writings on this wind are chiefly "Ueber Eiszeit, Föhn und Scirocco," 1867, and "Der Schweizer Fön," 1868. At this time, and even in his latest writings, he would not accept the views that Redfield had clearly expressed many years before concerning the cyclonic character of our alternating winds,—views that have found essentially universal acceptance since the establishment of the French and other weather services, and the publication of daily synoptic weather maps.

The dryness of the Fœhn was completely established by the observations of the Swiss meteorological stations soon after their foundation in 1863. At the same time the prevalence of moist, cloudy, or rainy winds on the other side of the Alps was also confirmed, and thus the warmth and dryness of the Fœhn were demonstrated to be of local origin. The problem thus became more sharply limited: there was to be discovered why the wind appeared, and how its physical conditions were determined. The cause of the wind was soon found to be associated with the approach of a cyclonic storm or area of low pressure on its ordinary path from the Atlantic to central Europe; and thus the Fœhn was seen to belong not to the general and permanent circulation of the atmosphere between equator and poles, but to the local, temporary, "accidental" disturbances of the atmosphere that we commonly call "storms." Wild, then of Zurich, now in St. Petersburg, was the first to bring out this important point in 1867 (Der Schweizer Föhn, Bern, 1868).

The origin of the wind should therefore be looked for, not on the further side of the mountains, whence it blows, but in the

direction towards which it flows; and in this view there is all the more need of finding a local origin for its physical conditions. Its warmth and dryness were first properly, but as will be seen not fully, explained as follows: When a current of air, moving on its oblique path towards a centre of low pressure, encounters a transverse mountain-range, and is forced to ascend over it, the air expands, and is thereby cooled, as has already been described; in consequence of the cooling, its vapor is condensed into cloud, and soon begins to fall as rain, so that on reaching the summit of the range the air contains less vapor, although it is very moist and cloudy; its fall in temperature has decreased its absolute humidity, while increasing its relative humidity. It must be further noted that on account of the release of the energy before employed in maintaining the rain in the state of vapor, the cooling of the ascending current is considerably retarded; the rate of cooling in an ascending mass of saturated air being only from one-third to one-half as fast as in non-saturated air. As soon as the current begins its descent on the leeward slope of the range, it is warmed by compression; but until all its cloud is evaporated it warms as slowly as it cooled before: however, by reason of having lost some vapor that fell on the windward slope as rain, the cloud mass to be evaporated in descent is less than the total cloud mass formed in ascent; the descending current soon becomes clear, and then warms at the relatively rapid rate proper to non-saturated air, and as a consequence of warming faster than it cooled, it must reach the valley bottom as a warmer wind than it was on starting to ascend the other side of the mountains. Having lost some of its humidity and gained in temperature, it must be relatively dry; it is a Fœhn.

To whom shall the high credit for this explanation be given? Like certain other broad discoveries, this is one that belongs to many independent students, and the Swiss meteorologists have traced it back even to the writings of one of their naturalists, Ebel, in the early years of this century. I have not seen his works. Dove also, in 1852, stated the general process fairly enough, but did not apply it directly to the case in hand, nor did

he clearly state its effect on the relative humidity of the air (Die Verbreitung der Wärme auf der Oberfläche der Erde, Berlin, 1852, 3); and his other and later writings often present opinions so untenable that the leading Austrian meteorologist of our day has lately said, "It can hardly be questioned that Dove's utterly unphysical theories have for a long time retarded the progress of meteorology." Espy expressed similar views as early as 1841 (Philosophy of Storms), and again more definitely in 1857 (Fourth Meteorol. Report); in the latter year, after explaining the general principles of the process with great clearness, he said: "The theory also would indicate that during the great rains that take place north of the head of the Gulf of Venice and south of the Carnic Alps, there would be felt on the north slope of these Alps a very hot dry wind, such as the Sirocco is described to be" (Ibid. 153). Helmholtz made incidental explanation of the heat of the Fœhn, but without mentioning its dryness, in his lecture on "Ice and Glaciers," in 1865 (Popular wissensch. Vorträge, 1876, i. 97).

Dr. Hann's first article on the Fœhn appeared in 1866 ("Zur Frage über den Ursprung des Föhn," Zeitschr. für Meteorol. 1866, i. 257–263). He unconsciously repeats the explanations of his predecessors, but gives them better definition and carries them to a further application; for although he was then under the influence of Dove's theories of atmospheric circulation, he proved the local origin of both the dryness and warmth of the Swiss Fœhn, and moreover showed that a similar wind occurred in Greenland, descending from the plateau of inland ice, and therefore not possibly owing its warmth to the torrid zone. A still further account of the physical theory of the Fœhn is found in his next article, a year after ("Der Föhn in den österr. Alpen," ibid. 1867, ii. 433); and a little later he added the crucial test of the theory in his account of a north Fœhn wind felt in the *southern* valleys of the Alps ("Der Scirocco der Südalpen," ibid. 1868, iii. 561). If not priority of explanation, at least conclusiveness and completeness of discussion belong to Hann. Apart from its interest in a historical sense, this article offers so admirable an illustration of the truly scientific method of in-

vestigation that it deserves careful study by all who are fortunate enough to have access to it; unfortunately the periodical in which it was published is seldom found in this country. The observations employed were taken by Dürer, at Villa Carlotta, on Lake Como; for example, on Feb. 1, 1862, with north wind, the temperature was 71° F., and the relative humidity 12 per cent. in the afternoon; on the next morning the figures were 68° and 25 per cent., respectively; similar warmth and dryness were felt in all the southern valleys of the Alps, but in the open plains of Lombardy they were hardly perceptible; at the same time there were heavy rains, with northerly winds, on the northern slope of the mountains. Although called a Sirocco, its correspondence with the Fœhn is complete. The same article contains an important table presenting the rate of vertical decrease of temperature between pairs of stations of different altitudes on the windward and on the leeward side of the mountains. The average values are 0.48° C. and 1.00° C. per 100 metres, which agree wonderfully well with the values indicated by physical theory.

Only one element remains to be added to the explanation, but it is a significant one. Thus far the production of the Fœhn depends on the evolution of "latent heat" while the wind is rising and raining on the further side of the range; now it appears from more precise observations that the winter Fœhn is often felt in the northern valleys of the Alps a day, or even more, before any rain falls on the southern slope; and therefore, although the rain is an aid when it begins, it must in these cases be preceded by some other cause not dependent on the ascent of air towards the passes and the condensation of vapor on its way. The solution of the difficulty is as follows: The average rate of variation of temperature in the atmosphere is closely one degree Fahrenheit to three hundred feet of descent. Inasmuch as the air is less active than the ground in changing its temperature, this rate will be increased in the summer season and decreased in the winter; in winter the rise of temperature encountered in descending through the air is generally less than the gain of temperature given to a descending mass of air by

reason of its compression. If at such a time the air in a valley be withdrawn by flowing away in answer to the call of an area of low pressure, and its place be taken by air descending from the passes to windward, this simple fact of descent will require that the new supply of air shall be warmer than that which has moved away; it is necessarily very dry, because it gains capacity for vapor as its temperature rises, without gaining the vapor to satisfy its capacity. This is the first cause of the Fœhn, and explains in good part why it is more pronounced in winter than in summer; its discovery is entirely due to Dr. Hann. When the wind over the pass is well established, it may be joined by currents of air rising from the further slope; these soon become cloudy and yield rain, and then the second cause of the Fœhn is in operation, as already explained.

The need of the additional explanation was first shown clearly in an extended monograph by Dufour, of Lausanne, entitled "Recherches sur le Fœhn du 23 Septembre, 1866, en Suisse" (Bull. Soc. Vaud., 1868, ix. 506–589). It gives an elaborate account of the hot, dry, violent southerly winds felt on the date mentioned in the northern valleys of Switzerland. Their warmth became distinctly perceptible on the 22d and continued over the 23d, and only then did heavy rains begin to fall on the higher passes. The diurnal range of temperature was small at most valley stations, and at several places the temperatures reached on the 23d were the highest of the year. After this there could be little belief in the desert origin of the Fœhn, and one might think that the "latent heat" theory would also soon have received its needed supplement. But it did not for fifteen years, until Hann's discussion of the Fœhn in Bludenz appeared (Wiener, Akad. Sitsungsber., 1882, lxxxv. 2°, 416). This was based on a good series of observations kept at Bludenz, in the Tyrol, where the Fœhn is of frequent occurrence in strong development, and the demonstration of the two processes concerned in its production is so complete that there now seems to be nothing more to be said on the subject.

One point of contrast between the Fœhn and the weather of winter anticyclones needs especial mention. It may at first

sight seem indeed like blowing hot and cold with the same breath to refer both the warmth of the Fœhn and the cold of anticyclones to a period of descending upper air; but it must be remembered, first, that the air in anticyclones settles down to the ground slowly, so that the heat produced by compression and perceptible at isolated points of considerable altitude is overcome by the cold produced by radiation and conduction to the excessively cold ground; and second, that the Fœhn wind descends rapidly down the valleys, so that there is no time to overcome much of its gain of heat. Out on the open country, where it has travelled some distance with small descent, its peculiar characteristics are lost. Its motion is rapid, not only because the air current is concentrated by the configuration of the ground, but also on account of the strong gradients characteristic of the leeward slope of a mountain range, where easy motion of air and consequent equalization of pressures are greatly hindered by the mountain obstruction.

The literature of the Swiss Fœhn is very extended. In addition to the titles already given, the following may be of value to the student of mountain meteorology: the last-named will lead him to many others.

G. W. Röder. Der Föhnwind in seinen phys. u. meteorol. Erscheinungen und Wirkungen. Wetterauischer Gesell. Jahresber., 1864, 1–32.

J. Coaz. Der Föhn. Chur Jahresber., 1867–1868, xiii. 89–111.

A. Muhry. Ueber den Föhnwind. Zeitschr. für Meteorol., 1867, ii. 385–397. This contains a review of the reports from the Swiss meteorological stations, in which the dryness of the Fœhn, then in dispute, was demonstrated by systematic observations.

Wettstein. Die Strömungen des Festen, Flüssigen und Gasförmigen, etc., Zurich, 1880, 332–366. An interesting chapter, giving several synoptic weather-maps during Fœhn conditions in Switzerland, and statistical illustration of numerous examples. The annual number of distinct Fœhn winds in Switzerland is as follows: 1864, 11; 1865, 16; 1866, 19; 1867, 19; 1868, 14; 1869, 19; 1870, 17.

Hann. Einige Bemerkungen zur Entwickelungs-Geschichte der Ansichten über den Ursprung des Föhns. Meteorol. Zeitschr., 1885, ii. 393.

Reference may perhaps also be made to a graphic explanation of the Fœhn by the writer in *Science*, 1886, vii. 55.

G. Berndt. Der Alpenföhn in seinem Einfluss auf Natur- und Menschanleben. Peterm. Mittheil., Ergänzungsh., 1886, 83. An extended review of the effects of the Fœhn, with good illustration of the valleys in which it is most frequently felt, and of the general weather conditions in which it is formed.

As soon as it was perceived that the physical characteristics of the Fœhn originated only during its descent from the Alpine passes, it became evident that a corresponding warm and dry wind should be found in other mountainous countries under similar conditions. Observation has abundantly proved this to be the case.

Espy seems to have been the first to recognize the wide occurrence of winds of this class. He quotes an extract given by Coffin in his "Winds of the Globe," from a letter from the Rev. Justin Perkins, residing in Persia, on the north-eastern declivity of a high mountain. "About once a month, ordinarily, we have a strong wind, often violent, from the west, which is the simoom, or samiel, from the Arabian desert. It usually continues about three days; and though its noxious properties are much neutralized by its passage over a distance of hundreds of miles, and across the high, snowy Koordish mountains, it is still warm and often hot here, and very debilitating to men and animals, and it is often so dry and hot here as to wither and crisp vegetables." Espy did not accept the desert origin of this hot wind, but attributed it to a rainy ascending wind on the other side of the mountains (Fourth Met. Report, 1857, p. 147). His explanation of the warm wind in Switzerland has already been quoted; he mentions still other localities, the eastern slope of the Rocky Mountains among them, of which more below.

Dove's explanation of the warmth of a wind on the leeward side of a mountain range was also given as a general statement, not limited to the Alps; but he does not add definite examples.

The Fœhn of Greenland, as represented by Hann from Rink's observations, is as extraordinary a wind as its relative in Switzerland, and possesses a special interest as being the first non-Alpine example of the kind presented in European writings. It is felt on the west coast, blowing from the east or south-east, and therefore flowing over the high ice-plateau of the interior, and down

the deep marginal fjords; it comes after a calm marked by low pressure and high-floating clouds, and then begins suddenly with high temperature and transparent air, first whirling the snow on the highlands, and later descending to lower levels; the temperature rises from 20° to 34° or even 45° F. over the winter mean; the dryness is excessive, and the snow is evaporated from the ground without melting. (Hann, Zeitschr. für Meteorol., 1866, i. 259; Klimatologie, p. 218. Rink's papers are "Beschreibung von Nord- und Südgrönland," Zeitschr. für allg. Erdk. 1854, ii. 207–210.) Hoffmeyer (Le Fœhn du Groenland, Copenhagen, 1877) gives an admirable account of this wind. One of the best examples of its occurence was during nine consecutive days in November and December, 1875, when it was as warm in western Greenland as in northern Italy, and warmer than in Canada, Iceland, Great Britain, and on the intervening Atlantic. At Upernavik it was warmer in the darkness of the polar night than at noon in France! No warm Sahara can here be appealed to as the source of the warm east-wind; its warmth is of local origin, by compression during descent from the icy plateau of the interior, moving in obedience to baric gradients about an area of low pressure at the mouth of Baffin's Bay, and high pressure near Iceland.

W. M. Davis.

[CONCLUDED IN SEPTEMBER NUMBER].

BOOKS AND PERIODICALS RECEIVED JULY 6-25.

Memorials of a Half Century. By Bela Hubbard. New York and London: G. P. Putnam's Sons.

Bulletin of the American Geographical Society, published quarterly. Printed for the Society. No 11 West 27th St. New York.

Revue Coloniale Internationale, for July. J. H. DeBussy, 60 Rokin, Amsterdam.

Ciel et Terre, July. Revue Populaire D'astronomie, de Metorologie et de Physique du globe. Brussels: National Institute of Geography.

American Journal of Science, July. New Haven, Conn.: J. D. & E. S. Dana.

Monthly Bulletin of the Moncalieri Observatory, June. Meteorological Society. Turin.

Journal of the Franklin Institute, July. Franklin Institute. Philadelphia.

MONTHLY PUBLICATION OF THE IMPERIAL OBSERVATORY AT RIO DE JANEIRO. May, 1887.

NOTES AND QUERIES. July and August. S. C. and L. M. Gould. Manchester, N. H.

DAS WETTER. June, 1887. Dr. R. Assmann, Braunschweig.

THE ELECTRICIAN AND ELECTRICAL ENGINEER, July. Monthly Review of Theoretical and applied Science. Electrical Pub. Co., New York.

ELECTRICAL REVIEW. Weekly, July 9-16. Electrical Review Publishing Co., New York.

MONTHLY WEATHER REVIEW, June. Meteorological Service, Toronto, Canada.

MEDICAL ADVANCE, July. H. C. Allen, Editor and Publisher, Ann Arbor, Michigan. London: Butcher & Co., 315 Regent St.

THE SANITARY NEWS. July 9, 16-23. Chicago, Ill. 134 Van Buren Street.

AMERICAN JOURNAL OF EDUCATION, July. St. Louis, Mo.

DECREE OF ESTABLISHMENT AND PLAN OF ORGANIZATION OF THE METEOROLOGICAL SERVICE AT CORDOBA, Argentine Rep. Official Edition.

ANNUAL METEOROLOGICAL REVIEW OF THE STATE OF CALIFORNIA. State. Sacremento, California.

THE PUBLISHER'S BULLETIN, June. New York.

SCIENTIFIC AMERICAN. Munn & Co., New York.

REPORT OF THE DEPARTMENT OF AGRICULTURE. July, 1887. Washington, D. C. Government Printing Office.

THE CHRONICLE. Fortnightly. July 11. Chronicle Associations. Ann Arbor, Mich.

STATE BOARD OF HEALTH BULLETIN, for the month ending June 30. Nashville, Tenn.

WEEKLY MET. BULLETIN. By Sergt. L. A. Jesunofsky. July 5, 12, 18. Nashville, Tenn.

STATEMENT OF MORTALITY AND DAILY METEOROLOGICAL OBSERVATIONS. For the week ending June 25. Board of Health, Buffalo, New York.

MICHIGAN CROP REPORT AND FIFTH MONTHLY REPORT OF THE MICHIGAN ST. WEATHER SERVICE, June. Publisher by Sec. of St. Lansing, Mich.

MINNESOTA SIGNAL SERVICE REPORT, June. St. Paul, Chamber of Commerce, co-operating with the Signal Service.

MISSOURI ST. WEATHER SERVICE, June. I. M. Johanson, Assistant in Charge, Washington Univ.

CAUSES AND PREVENTION OF INFANTILE DIARRHŒEAL DISEASES. F. B. Campbell, A. M., M. D., Buffalo, N. Y.

IOWA WEATHER BULLETIN, June. Gustavus Hinrich's Central Station, Iowa.

MONTHLY PUBLICATION OF THE IMPERIAL OBSERVATORY AT RIO DE JANEIRO. May, 1887.

NOTES AND QUERIES. July and August. S. C. and L. M. Gould. Manchester, N. H.

DAS WETTER. June, 1887. Dr. R. Assmann, Braunschweig.

THE ELECTRICIAN AND ELECTRICAL ENGINEER, July. Monthly Review of Theoretical and applied Science. Electrical Pub. Co., New York.

ELECTRICAL REVIEW. Weekly, July 9-16. Electrical Review Publishing Co., New York.

MONTHLY WEATHER REVIEW, June. Meteorological Service, Toronto, Canada.

MEDICAL ADVANCE, July. H. C. Allen, Editor and Publisher, Ann Arbor, Michigan. London: Butcher & Co., 315 Regent St.

THE SANITARY NEWS. July 9, 16-23. Chicago, Ill. 134 Van Buren Street.

AMERICAN JOURNAL OF EDUCATION, July. St. Louis, Mo.

DECREE OF ESTABLISHMENT AND PLAN OF ORGANIZATION OF THE METEOROLOGICAL SERVICE AT CORDOBA, Argentine Rep. Official Edition.

ANNUAL METEOROLOGICAL REVIEW OF THE STATE OF CALIFORNIA. State. Sacremento, California.

THE PUBLISHER'S BULLETIN, June. New York.

SCIENTIFIC AMERICAN. Munn & Co., New York.

REPORT OF THE DEPARTMENT OF AGRICULTURE. July, 1887. Washington, D. C. Government Printing Office.

THE CHRONICLE. Fortnightly. July 11. Chronicle Associations. Ann Arbor, Mich.

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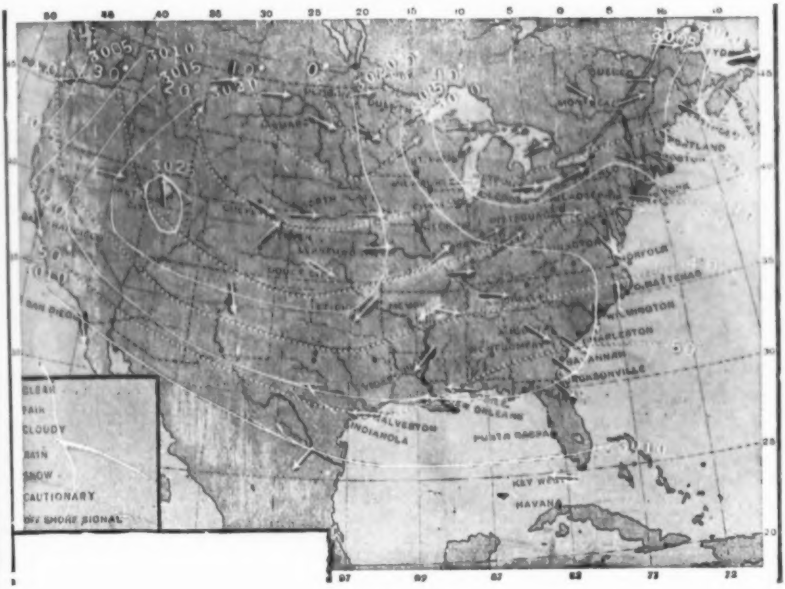
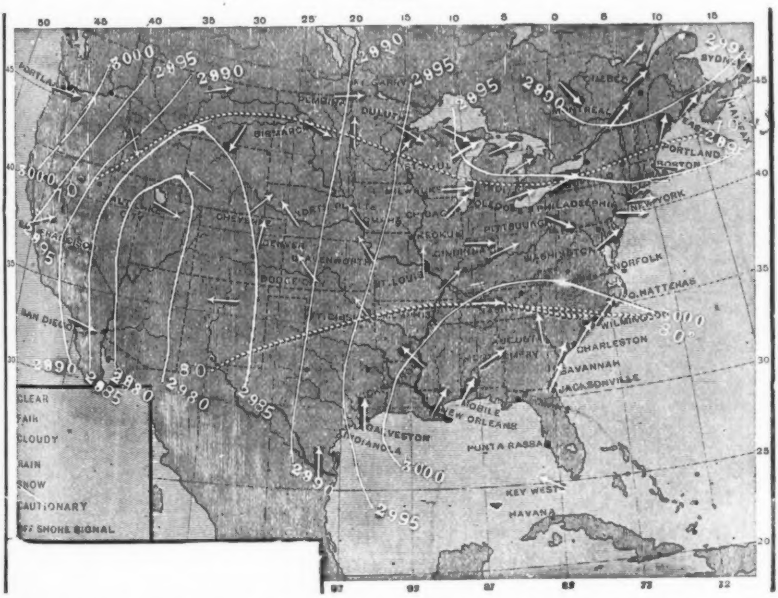
IOWA WEATHER BULLETIN, June. Gustavus Hinrich's Central Station, Iowa.

FIFTEEN YEARS' NORMAL PRESSURE, TEMPERATURE, AND WIND DIRECTION (LAMBERT'S FORMULA).

JANUARY.



JULY.



These plates belong with the article on "Reduction of Air Pressure to Sea Level" published in the June number.